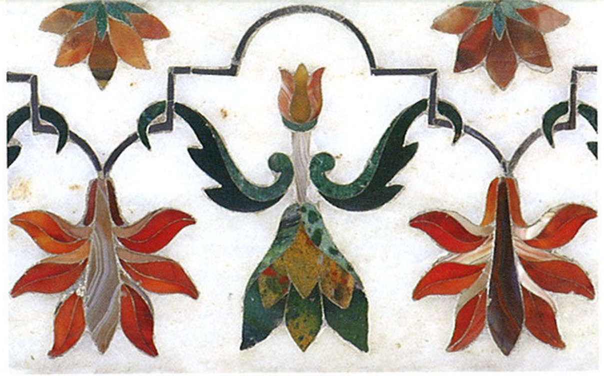
THE MOONLIGHT GARDEN

NEW DISCOVERIES AT THE TAJ MAHAL



Waterworks and Landscape Design in the Mahtab Bagh

James L. Wescoat Jr.

A sign for them is the land that is dead;
We do give it life, and produce grain therefrom, of which they do eat;
And we produce gardens with palm trees and vines;
And we do cause springs to gush forth therein.

KORAN 36:34, *inscription, outer west arch, Taj Mahal tomb*

FERRYING THE Yamuna River from the Taj Mahal to the Mahtab Bagh (Moonlight Garden), one wonders how moonlight danced in reflections on the river surface, in garden fountains, and through trees along the banks (figs. 1, 2). Even today, the daily lives of many Agra residents begin along the riverbanks—bathing, offering prayers, crossing to work. How, then, has this sacred river become so terribly depleted and polluted—almost dead—bubbling with anaerobic decomposition, drifting plastic bags, and refuse until monsoon rains release waters, sometimes floods, from upstream barrages? It is only then that fish splash, perhaps delighting in monsoon flows, perhaps struggling for oxygenated water at the river's surface. Extreme temperatures, fluctuating flows, purity, and pollution remind us that Mughal garden waterworks have played an important role refreshing plants and visitors alike (fig. 3).

Garden historians have celebrated the aesthetic, functional, and symbolic qualities of waterworks built during the Mughal dynasty (1526–1858). Understanding these waterworks requires a balance of poetics and practicality—a designer's as well as garden historian's perspective. We may begin by imagining tall marble fountains in a large, octagonal, lotus-foliated, pavilion-lined pool. Fountains accompany musicians and poets in the open sandstone pavilions while the Yamuna murmurs beyond. Water cascades over illuminated niches into a

Figure 1. Sunset along the Agra riverfront at the Taj Mahal, 1999. Photograph by Neil Greentree

crisply carved sandstone pool. Irrigated fruit trees, flowering shrubs, and bulbs line the garden paths.

To refine these poetic images, we want to know how much water the plants, pools, and pavilions required; where those waters came from; and how drainage and floodwaters returned to the river. Evidence is scarce—scattered across texts, paintings, prints, and the site itself. To fill gaps, we may seek comparable water features at the Taj Mahal and other riverfront gardens in Agra[1]

Reconstructing these historic water systems, experiences, and meanings is the aim of this essay, which "follows the water"—from the requirements of the garden (water demand), to withdrawals from the Yamuna River and distribution through terracotta pipes (water supply), to fountains and pools (display and experience), and ultimately, its return to the Yamuna (drainage and flooding). A series of monumental inscriptions in the Taj Mahal, drawn from the Koran, parallels this sequence of water themes, sheds light on their meanings, and inspires the narrative that follows.

Page 58: *The Delivery of Presents for Prince Dara-Shikoh's Wedding*, attributed to Bishandas; India, ca. 1635. Opaque watercolor and gold on paper; folio 120b: image area 33 x 23 cm. From the *Padshahnama, Chronicle of the King of the World.* Given by the Nawab of Oudh to George III in 1799. The Royal Collection © 2000, Her Majesty Queen Elizabeth II. (See detail, fig. 9, page 67.)

Figure 2. Reflections of the Taj Mahal in the Yamuna River, viewed from the Mahtab Bagh, 1999. Photograph by Neil Greentree

WATER DEMAND

> They and their wives will be in groves of shade,
> reclining on raised couches;
> Fruit will be there for them;
> And they shall have whatever they call for.
>
> KORAN 36:55–57, *inscription, outer north arch, Taj Mahal*

The Mahtab Bagh encompasses about 9.7 hectares (24 acres), irrigated as well as rain fed, with elaborate waterworks along the Yamuna riverfront (fig. 4). Water was supplied from a gallery of wells, an aqueduct, and a cistern that drew water from the Yamuna at the southwest corner of the garden (see "Archaeology of the Garden"). Terracotta pipes delivered water from the tank to twenty-five fountains in a large octagonal pool, surrounded by lotus foliation common in Mughal pools. When the pool was full, water passed through a shallow channel at its northern end, over a sandstone lip that created a miniature waterfall in front of three rows of sandstone *chinikhanas* (small niches for oil lamps or flowers), into a small sandstone pool at their base (fig. 5). From that lower pool, the flow and fate of the water are a mystery. Aside from small drains into the garden, there are no clear links to axial channels of the sort one expects in a Mughal garden. In the center of the garden, however, there is

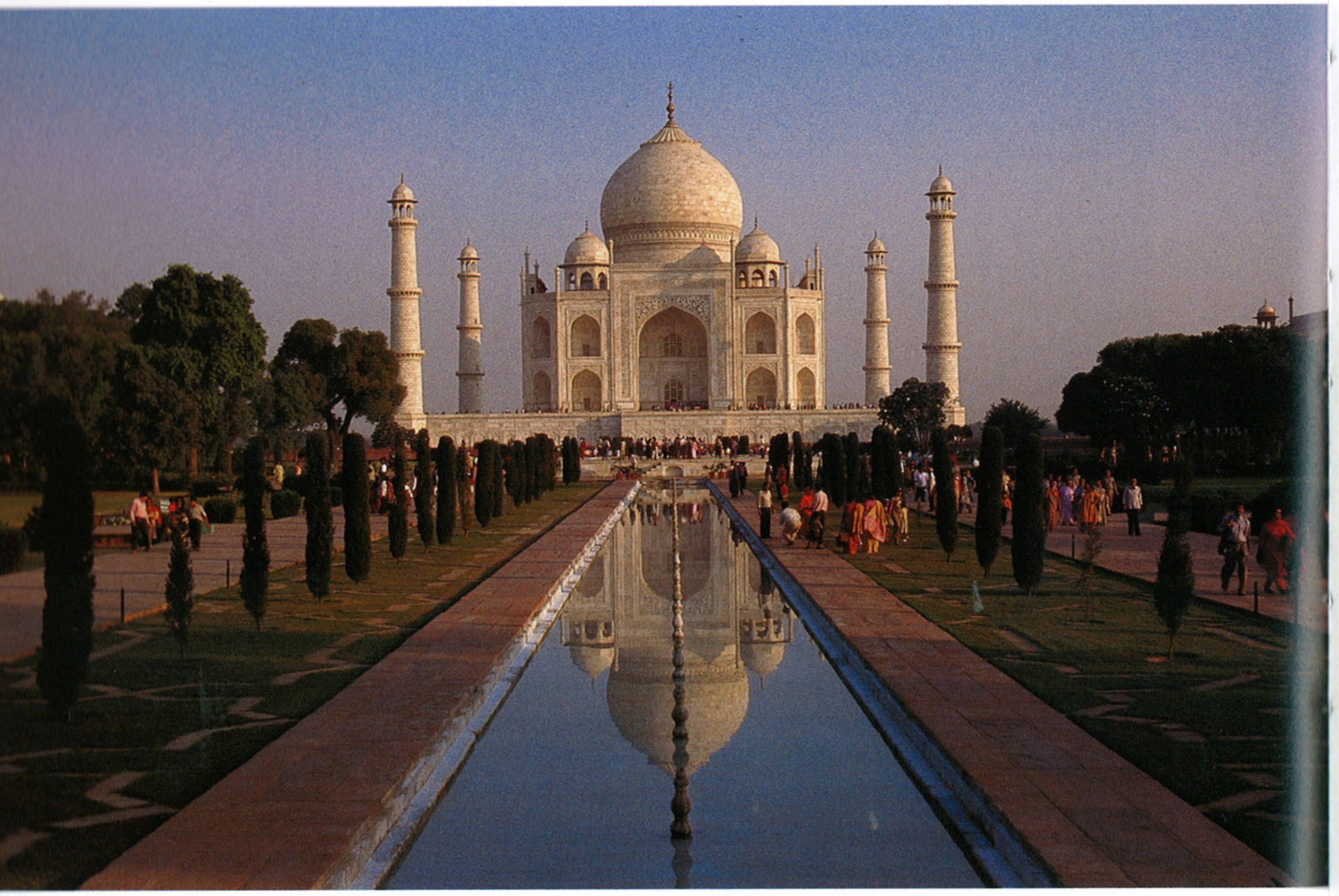


Figure 3. Pool and fountains at the Taj Mahal, 1999. Photograph by Neil Greentree

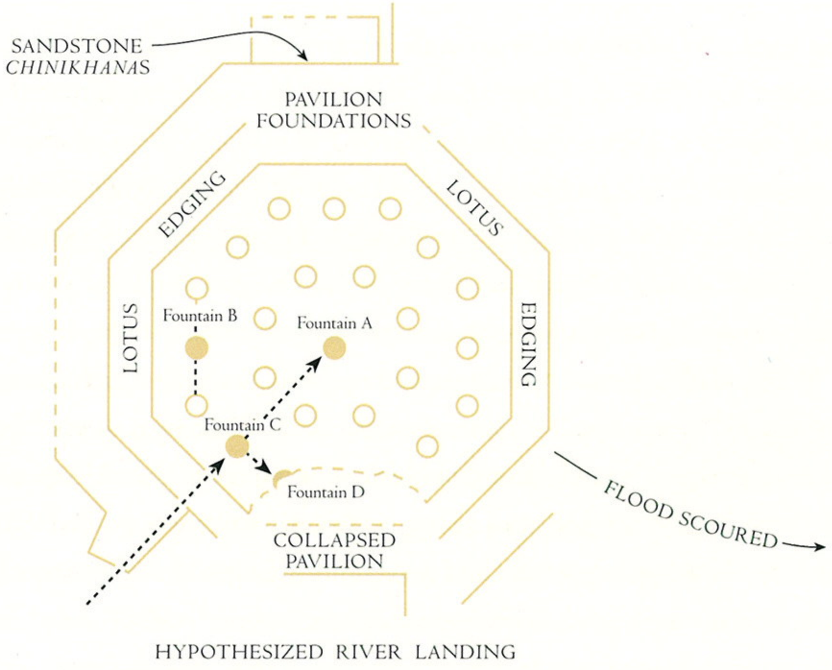
another small tank, 6.9 meters on a side and 1.4 meters deep, which reinforces the view that this was a *charbagh* (fourfold garden), though no crosswalks, water channels, or pipes have survived.[2] One small undated brick-lined well stands near the garden axis, perhaps built to irrigate plantings of the Mughal era or later. Drainage channels returned excess water from the octagonal pool to the Yamuna. Floods scoured the riverfront, removing whatever landing existed, depositing more than a meter of silt, and undercutting the southern end of the octagonal pool and pavilions so deeply that they collapsed.

How much water did this garden require? To answer this question, we may begin with the climate and hydrology of Agra. Although we have no paleoclimatic data for Agra, we can construct a modern "water budget" that tells an interesting story about plant water needs (fig. 6).[3] The water budget consists of four key variables: Precipitation (P); Potential Evapotranspiration (PE)—the amount of water plants would need if fully irrigated; Actual Evapotranspiration (AE, which equals PE–P)—the amount plants actually use; and Deficit (D, which equals PE–AE)—the gap between plant water needs and actual use. These four variables indicate that water supply and demand are balanced in January, after which rapidly increasing water deficits and plant stress occur through June, when the monsoon breaks. Monsoon precipitation in July so greatly exceeds plant water needs (AE) that water runs off into ephemeral streams and back to the Yamuna River. After August, however, plants use up soil moisture, creating severe plant stress in October that subsides only during the winter months, when precipitation and evapotranspiration once again converge. Although native plants are adapted to these seasonal moisture deficits, exotics could suffer terribly unless provided with irrigation water in amounts and timings to match the deficits indicated on figure 6.

To irrigate the Mahtab Bagh plantings, waterworks would have had to deliver a volume of water equal to the depth of the annual water deficit times the area of the garden plantings (855 mm x 9.3 hectares, which equals approximately 79,600 cubic meters, or 64.5 "acre-feet," a common unit of irrigation measurement). This estimate of average garden water needs is complicated by several factors. Weather varies from year to year, especially in monsoon regions. Modern data indicate dramatic variation in seasonal and interannual rainfall in Agra.[4] A well-designed irrigation system accommodates dry years and drought periods as well as average conditions. Climate (defined as average weather conditions over thirty years) also varies over periods of decades and centuries. Although climatic conditions that prevailed when the garden was created varied in subsequent decades, it is difficult to distinguish climatic effects from human transformations of vegetation in the pollen record from the Mughal period onwards.[5]

The Yamuna River added two further complications. Monsoon flows recharged the alluvial aquifer, providing soil moisture for deeply

Figure 4. Overview of waterworks on the Mahtab Bagh waterfront.



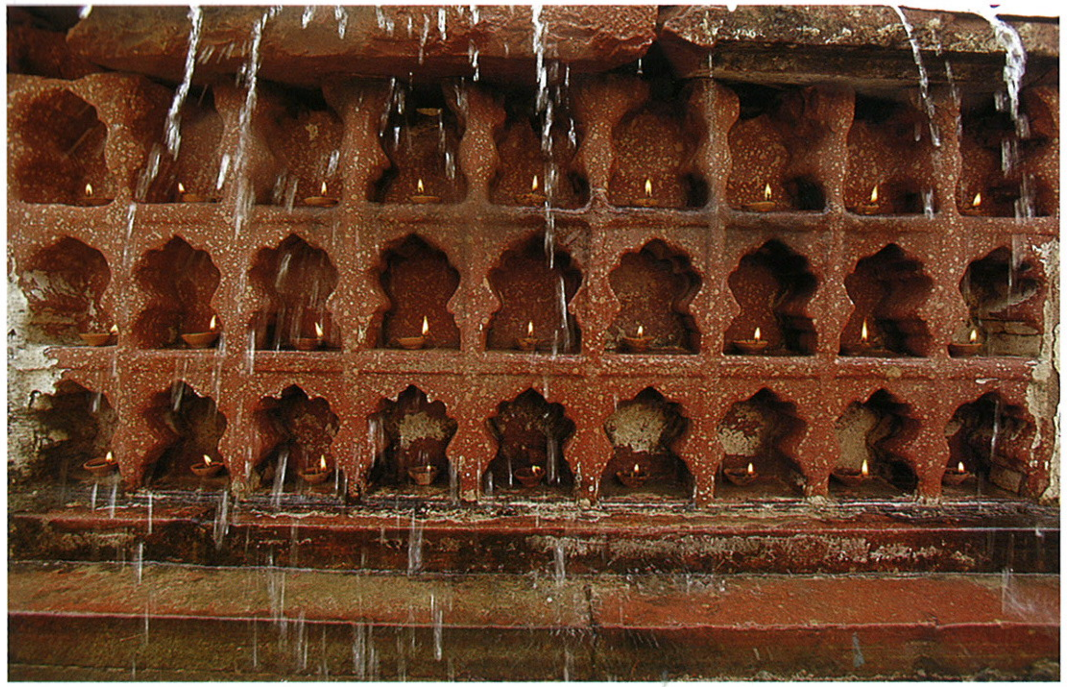


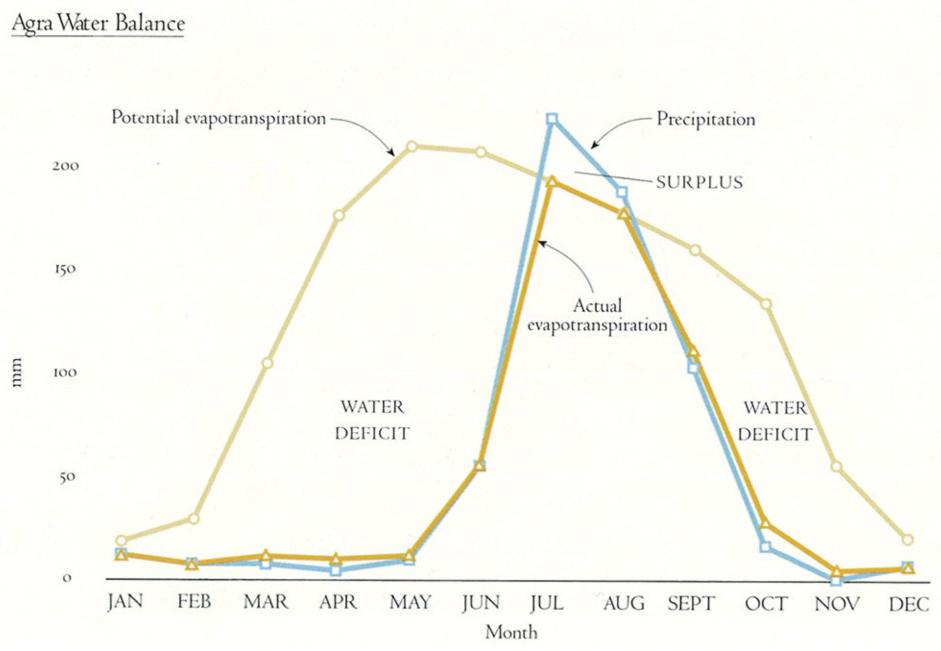
Figure 5. A miniature waterfall passed in front of these *chinikhanas*, or small niches for oil lamps or flowers, at the Mahtab Bagh, 1999. Photograph by Neil Greentree

rooted trees along the riverbank. But garden walls extended several meters below the surface blocking some of those subsurface flows. Flood flows penetrated garden walls, recharging soil moisture but also depositing sediments (primarily sand) that harmed garden plantings at least over the short term.

Although flooding was a perennial problem, the Yamuna River channel is remarkably stable at Agra, accounting for the survival of riverfront garden pavilions and towers. In Delhi, the second Mughal ruler, Humayun, is buried in a tomb-garden that was originally on the riverfront but now lies far from the modern channel. In Lahore, the Ravi River flows a kilometer west from its original channel near Lahore Fort and encircles the *baradari* (open pavilion) garden of Prince Kamran (brother of Humayun, died 1556) that once stood on the opposite bank.[6] Only Agra retains the broad traces of Mughal riverfront design.

In addition to its plantings, Mahtab Bagh had extensive water features. To estimate their water demand, we may calculate the volume of water needed to fill and run the features at any moment in time. Figure 7 indicates what can be roughly estimated from extant features.

While plantings may have consumed up to 64.5 acre-feet, each filling of the waterworks required 1.5 acre-feet (or 2 percent of the total). Some of the water in pools may have come from monsoon precipitation, but much more water would have evaporated. To actually "run" the fountains, kitchen, and toilets, additional water was needed. How much water depends on the frequency, nature, and duration of garden use—about which we know very little. If intermittently used, waterworks may have had one refilling (i.e., 3 acre-feet); if seasonally or annually used, two to three refillings (up to 6 acre-feet).



Landscape Architectural Water Demand

Feature	Estimated Volume (m^3)	Speculated Volume (m^3)*
Octagonal pool	1510	—
Fountain network and jets	11	—
Cascade and small pools	6	—
Central water tank	45	—
Aqueduct	34	—
Cistern	8	—
Hypothesized water axes		60
Other/unknown		
(e.g., baths, toilets, drains, and kitchen) +10%		170
Subtotal Waterworks	—	1840 m^3
(Equals approx. 1.5 acre-feet [AF])		(1.5 AF)
Plant water requirements subtotal		79,600 m^3
		(64.5 AF)
Total (assuming only one filling of waterworks)		81,440 m^3
		(~66.0 AF)

*Crude estimates rounded to the nearest 10 m^3 . Based on 1998 field research.

Figure 6. Water balance diagram for modern Agra.

Figure 7. Landscape architectural water demand estimated from surface data at the Mahtab Bagh.

A fully irrigated garden with continuous fountain displays might have required 70 acre-feet per year. This figure corresponds with the amount of water used by approximately 70 modern suburban households of four in the United States—or 200 urban households in Uttar Pradesh! It seems unlikely that the full irrigation requirement was supplied to a garden rarely visited by Shahjahan and only occasionally by other members of the royal family. Deficit irrigation is a common practice. But it also seems unlikely that the surviving aqueduct and cistern could have supplied even a major fraction of the water needed. They could certainly have kept the fountains running, and perhaps have filled the pool once or twice (a volume 36 times that of the aqueduct and cistern). But the aqueduct and cistern would have to be filled nineteen hundred additional times to irrigate the garden. Two thousand fillings per year is a lot for such a small structure, suggesting that there were additional sources of supply or other scenarios of garden water use. Before drawing any conclusions, it is useful to take a closer look at the waterworks.

WATER SUPPLY: LIFTING, STORAGE, AND DISTRIBUTION

> Say: "What think ye? If in the morning your streams should have sunk into the earth, who then shall give you clear and running water?"
>
> KORAN 67:30, *inscription, inside southeast arch, Taj Mahal*

The Mahtab Bagh fountains were supplied from a gallery of shallow wells along the Yamuna River. In many gardens river diversions and wells operated independently, but they were directly linked at the Mahtab Bagh. An eighteenth-century map (see "Archaeology of the Garden," fig. 1) depicts a line of four wells, while A. C. L. Carlleyle, in a report for Agra in 1871–72 mentions nine.[7] Only one was visible in 1996, but none in 1998, when the well appears to have been covered by a thin layer of earth in the local garden. These brick-lined wells offered two advantages over direct diversions from the river: they provided a fixed point of access, even when river levels fluctuated, and they filtered sediments from the river water. Riverfront wells served as desilting basins as well as water sources.

The original depth of these wells is unknown. Also unknown are the means of lifting water from them into the short aqueduct. Water-lifting devices at the Taj Mahal and the tomb-garden of I'timauddawla (died 1621; grandfather of Mumtaz Mahal and prime minister under the third Mughal ruler, Jahangir) involved *purs* (leather buckets lifted by ropes), pulled by bullocks walking down an inclined slope (figs. 8, 9).[8] Although Babur criticized these devices as unsanitary and advocated the Persian wheel (*rehant*—a chain of ceramic pots lifted over a gear-driven wheel turned by bullocks), the latter do not seem to have been used in the Taj Mahal-Mahtab Bagh complex.

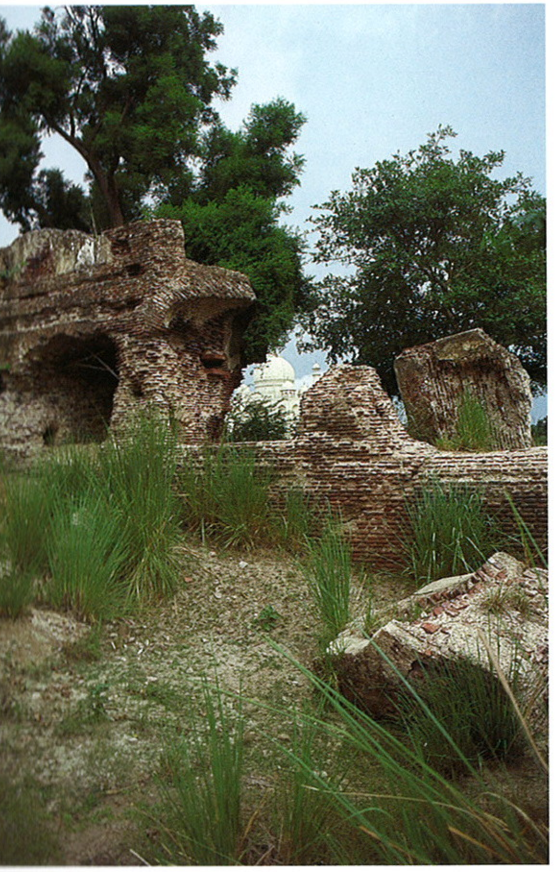
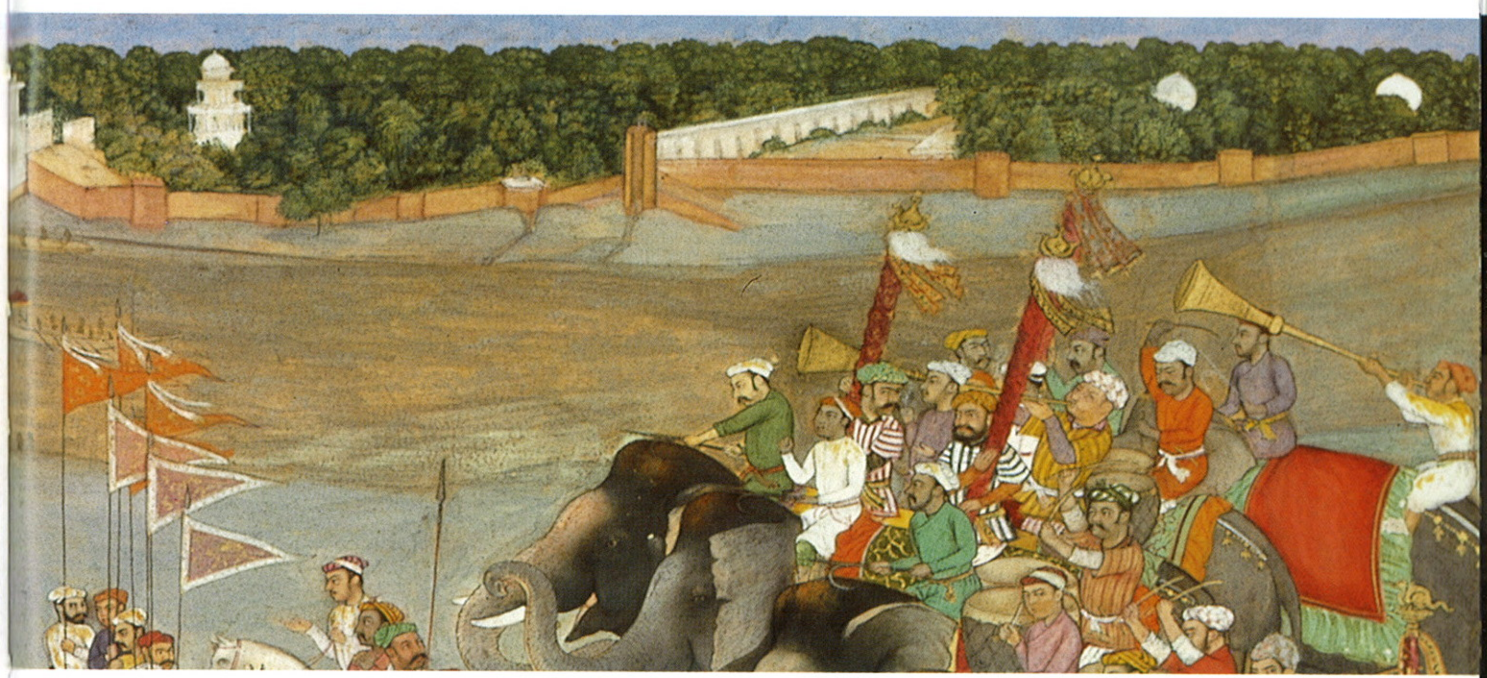


Figure 8. Remnants of the Mahtab Bagh aqueduct, 1999. Photograph by James L. Wescoat



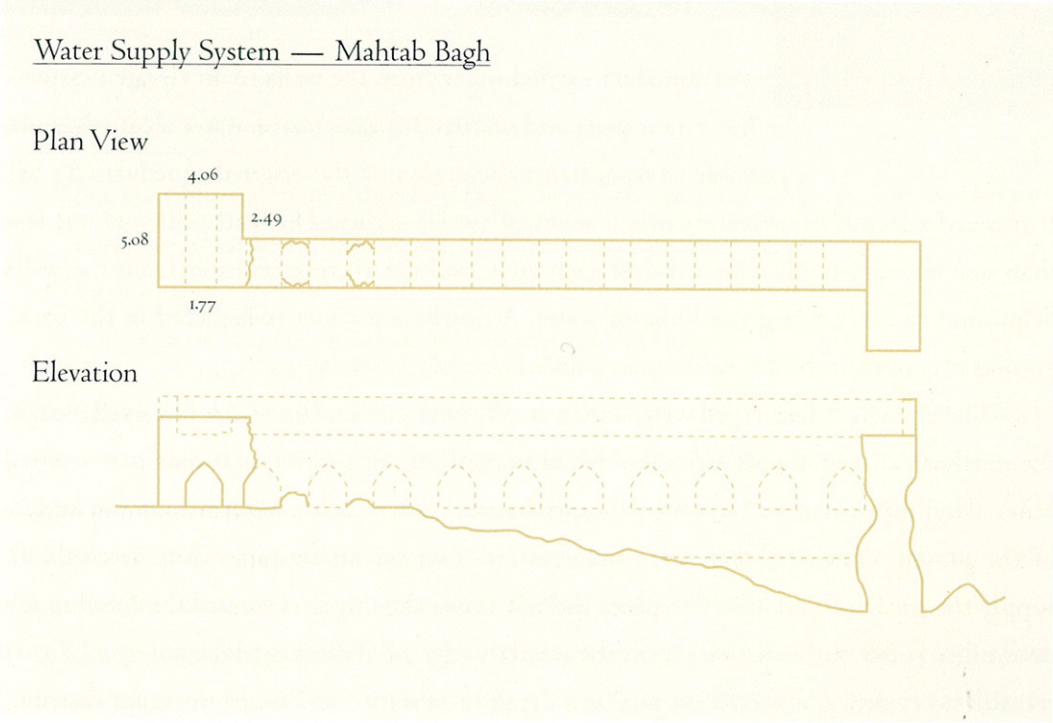


Figure 9. Detail, *The Delivery of Presents for Prince Dara-Shikoh's Wedding* The background of this processional scene, shown in full on page 58, depicts the walled garden enclosures, buildings, waterworks, and water lifting devices along the northern banks of the Yamuna River. The long structure to the right is an aqueduct. These structures resemble the Mahtab Bagh.

Figure 10. North elevation of the Mahtab Bagh aqueduct, reconstructed from extant piers and aqueduct fragments.

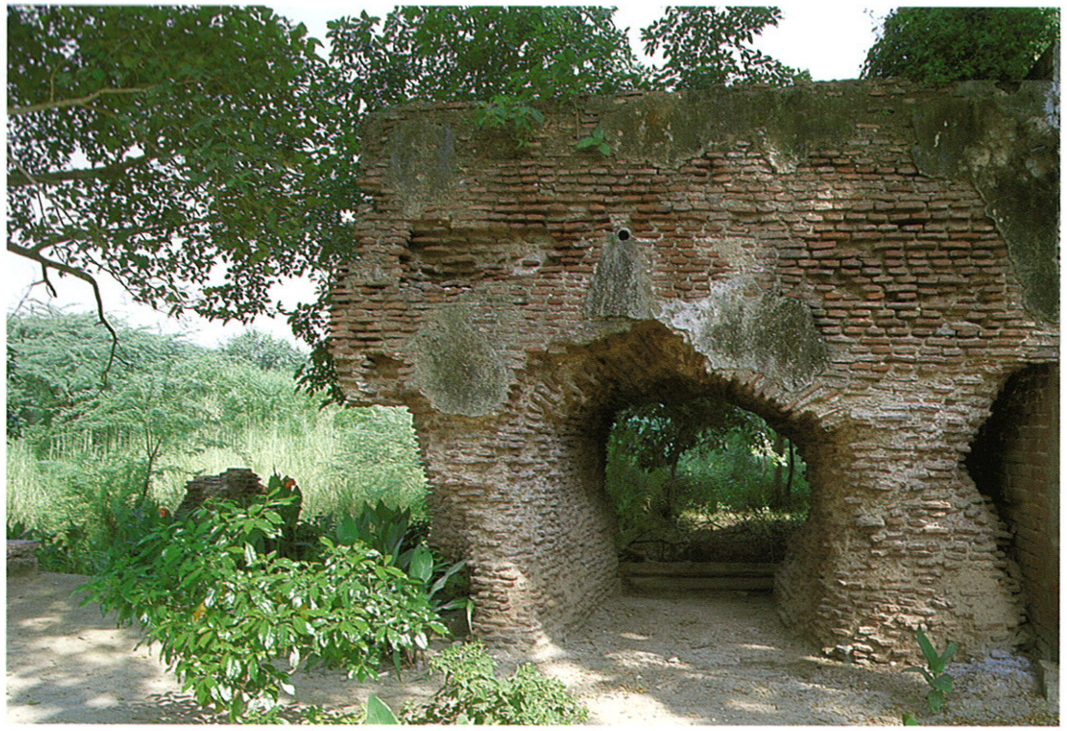


Figure 11. Ruins of cistern, Mahtab Bagh, 1999. Photograph by Neil Greentree

An aqueduct carried water from the wells to an elevated cistern. The five extant piers and scattered fragments of water channels make it possible to reconstruct the design of the original aqueduct (fig. 10). It traveled a length of 35 meters over a series of twelve arches. The water channel was less than one meter deep. It widened over each arch, perhaps to receive water from the wells below and to carry a larger volume of water. A nearby aqueduct is depicted in the background of a work from the *Padshahnama* painted circa 1635[9] (see fig. 9).

The aqueduct discharged water into a small water cistern (fig. 11). A plastered slot on the northern side of the water tank remains something of a mystery. It may have carried water along the garden wall toward the central water tank or other water uses in the middle of the garden. On the eastern side of the cistern, four terracotta pipes drop vertically to supply the garden fountains. The pipes did not travel directly east toward the fountains, a possibility ruled out by a test pit on the western edge of the octagonal pool in 1998 that revealed no evidence of terracotta pipe at a depth of two meters. Part of the water distribution system was discerned by cleaning out previously excavated fountain pits (fig. 12), which revealed that the central fountain A was fed by a single terracotta pipe from fountain C, which was fed in turn by a water supply line from the southwest.[10] Not all pits were connected to each other. Fountains B and D were connected only to their nearest neighbors on the outer ring. Supply to the middle ring remains a mystery, but the piping pattern suggests that the surviving cistern may not have served the entire fountain network.

The fountain pits are 1.6 meters deep and roughly 0.6 meters wide, set in a layered foundation of concrete, sandstone, and brick (fig. 13). They were fed by terracotta pipes, 13 centimeters in diameter, that discharged water to a plaster-lined bowl at the base of the fountain. In the Taj Mahal such bowls contained brass pots for pressure control. Fountain fragments excavated by the Archaeological Survey of India (ASI) and removed to a Taj Mahal storehouse indicate that white ribbed marble fountain shafts were seated on a base of red sandstone blocks (fig. 14).

Evidence from the water budget analysis, fountain pits, and *The Taj Mahel, Agra,* an eighteenth-century print by William and Thomas Daniell (see p. 32) suggests that there may have been a second aqueduct and cistern near the tower in the southeast corner of the garden.[11] Although no cartographic source indicates waterworks in that location, the area would have been subject to severe eddy scouring and erosion on the downstream side of the garden walls.

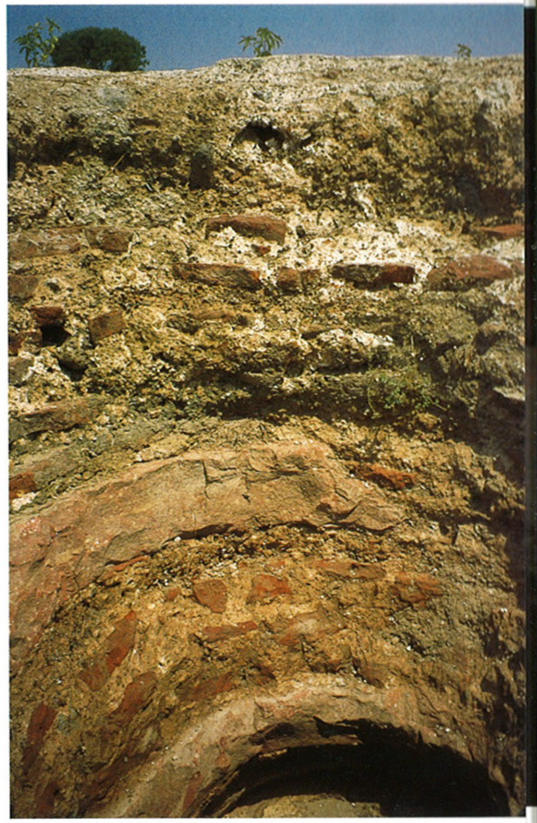


Figure 12. Fountain pit at the Mahtab Bagh, 1999. Photograph by Neil Greentree

WATER DISPLAY AND EXPERIENCE

> But the righteous shall drink of a cup mixed with camphor—A Fountain whereat the devotees of God do drink, causing it to flow forth in abundance.
>
> KORAN 76:5–6, *inscription, inside western arch, Taj Mahal*

The functional waterworks described above ultimately delivered water to an aesthetic sequence of fountains and pools. In the heat of May, the Mahtab Bagh established a cool microclimate through evaporation from the pools, cascades, and fountain jets. The *Padshahnama* and other images suggest that nighttime use may have been common, with fireworks illuminating the riverbanks and reflecting in the river.

The octagonal pool offered partial reflections of the Taj Mahal, as the Yamuna River does today during low flows in May (fig. 15). But just as the Yamuna produces fissured reflections during the monsoon, so too would fountains in the octagonal pool have dashed images of the Taj Mahal into a thousand dancing fragments. Those twenty-five monumental fountains presented a dramatic foreground to the Taj Mahal, which was visible above and through the *bangla* pavilion on the north side of the octagonal pool. On moonlit nights, reflected light from the Taj would have gently illuminated the Mahtab Bagh fountains, pool, and pavilions. The broad octagonal terrace would have been circumambulated, offering views of the fountains from all sides.

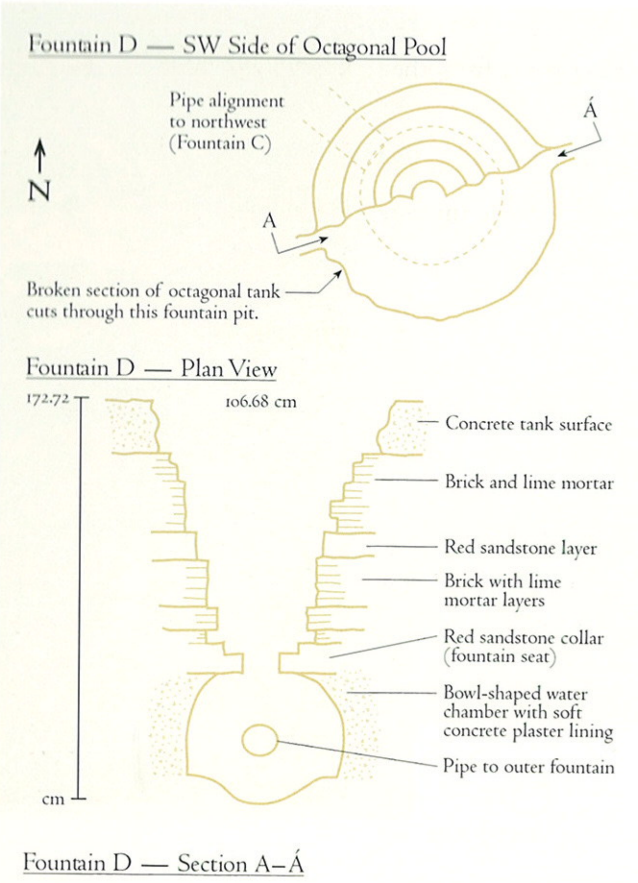

Fountain D — SW Side of Octagonal Pool
Pipe alignment to northwest (Fountain C)
N
A
Á
Broken section of octagonal tank cuts through this fountain pit.
Fountain D — Plan View
172.72
106.68 cm
cm
Concrete tank surface
Brick and lime mortar
Red sandstone layer
Brick with lime mortar layers
Red sandstone collar (fountain seat)
Bowl-shaped water chamber with soft concrete plaster lining
Pipe to outer fountain
Fountain D — Section A–Á

Figure 13. Cross section of the Mahtab Bagh fountain pit "D."

Although the octagonal pool roughly parallels the plan of the Taj Mahal tomb, it differs in width and form, as the Mahtab Bagh has a regular octagon shape while the Taj Mahal is a "Baghdadi octagon" whose chamfered corners are shorter than its sides. There may have been historical associations between the Mahtab Bagh pool and an earlier octagonal pool built by Babur on the left bank of the river (see "Reflections of Paradise"). Gulbadan Begum (died 1603, sister of Humayun and author of the *Humayunnama*) wrote of an octagonal tank in Humayun's Mystic House that doused unsuspecting young people at a feast, which reminds one of the *giocchi d'acqua* in Italian gardens at that time, and which is just one example of the complex aesthetic psychology of Mughal waterworks.[12] Humayun's mosque is the nearest Mughal monument to the Mahtab Bagh, and the octagonal pool may have alluded to these earlier tanks built by Babur and Humayun.

DRAINAGE AND FLOOD WATERS

> And a Sign for them is that We bore their own kind in the loaded Ark;
> And We created for them similar vessels whereon they ride.
> If it were our will we could drown them,
> Then there would be no one to help them.
>
> KORAN 36:43, *inscription, outer west arch, Taj Mahal tomb*

In December 1652, Prince Aurangzeb wrote to his father Shahjahan that the Taj Mahal dome was leaking and described what was done about it. He wrote that, "The Mahtab Garden was completely inundated, and therefore it has lost its charm, but soon it will regain its verdancy. The octagonal pool and the pavilion *(bangla)* around it are in splendid condition. It is surprising to hear that the waters of the Jumna have overflowed their banks because at present the river is moving back to its old course and is about to regain it[13] (see "Letter from Aurangzeb to Shahjahan," p. 28). Although Aurangzeb was later known as a "pious" ruler, his letter displays the ordinary concerns of a property owner affected by flood rather than the signs mentioned on the inscription from the Koran above.

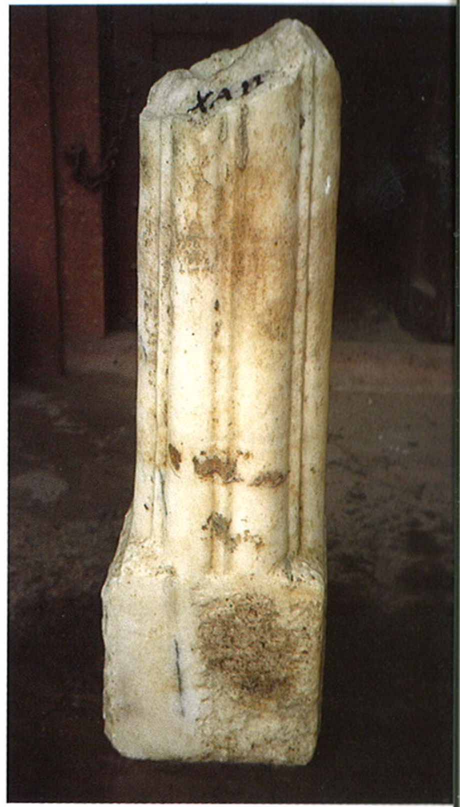


Figure 14. Marble fountain shaft from the Mahtab Bagh, stored in ASI building at the Taj Mahal, 1998. Photograph by James L. Wescoat

Prior to large-scale water diversions in the twentieth-century, flooding was a frequent phenomenon. But Agra is distinct among cities along the plains for the stability of its river channel and the solidity of its riverfront garden walls and piers that enabled the survival of riverfront gardens.[14] Eventually, the Mahtab Bagh was so frequently flooded that its pavilions were ruined, plantings swept away, and a massive tank collapsed. Drains could not carry away its excess waters. Floods lessened during this century, but flood losses have increased due to urbanization in the region. Tourism has grown but so have environmental problems. What do these trends mean for the future?

THE MEANINGS OF WATER

> And mingled therewith shall be the waters of Tasnim;
> A Fountain whereat do drink those nearest unto God.
>
> KORAN 83:27–28, *inscription, east side of the cenotaph, Mumtaz Mahal*

Beyond aesthetic experience, did the Mahtab Bagh waterworks have any special meaning? Mughal waterworks often connoted the Four Rivers of Paradise, but the Mahtab Bagh had a single prominent pool and channel. The fountains of paradise—Tasnim and Salsabil—are mentioned in inscriptions at the Taj Mahal but are not apparent in extant water features at the Mahtab Bagh.[15] The art historian Wayne Begley's mystical interpretation of the Taj Mahal, inspired by images from the Sufi cosmologist Ibn al-Arabi (died 1240), might be extended to the Mahtab Bagh, though Elizabeth Moynihan suggests the Yamuna River separates the pleasure garden of the living from the tomb-garden of the deceased (see "Reflections of Paradise").[16] The architectural historian Ebba Koch chides Begley for straying too far into Islamic cosmology when "All the evidence suggests rather that the aim of the planners was to perfect the earlier tradition of the waterfront garden, and then to enlarge it to a scale beyond the reach of ordinary mortals in order to create an ideal paradisical garden for the deceased."[17] But these two interpretations are not incompatible.

Another speculative possibility involves Shahjahan's frequent allusions to King Solomon. In one account, Solomon invites Queen Bilkis to enter the palace. She mistakes the polished floor for water and raises her skirt, baring her legs. When Solomon reveals the

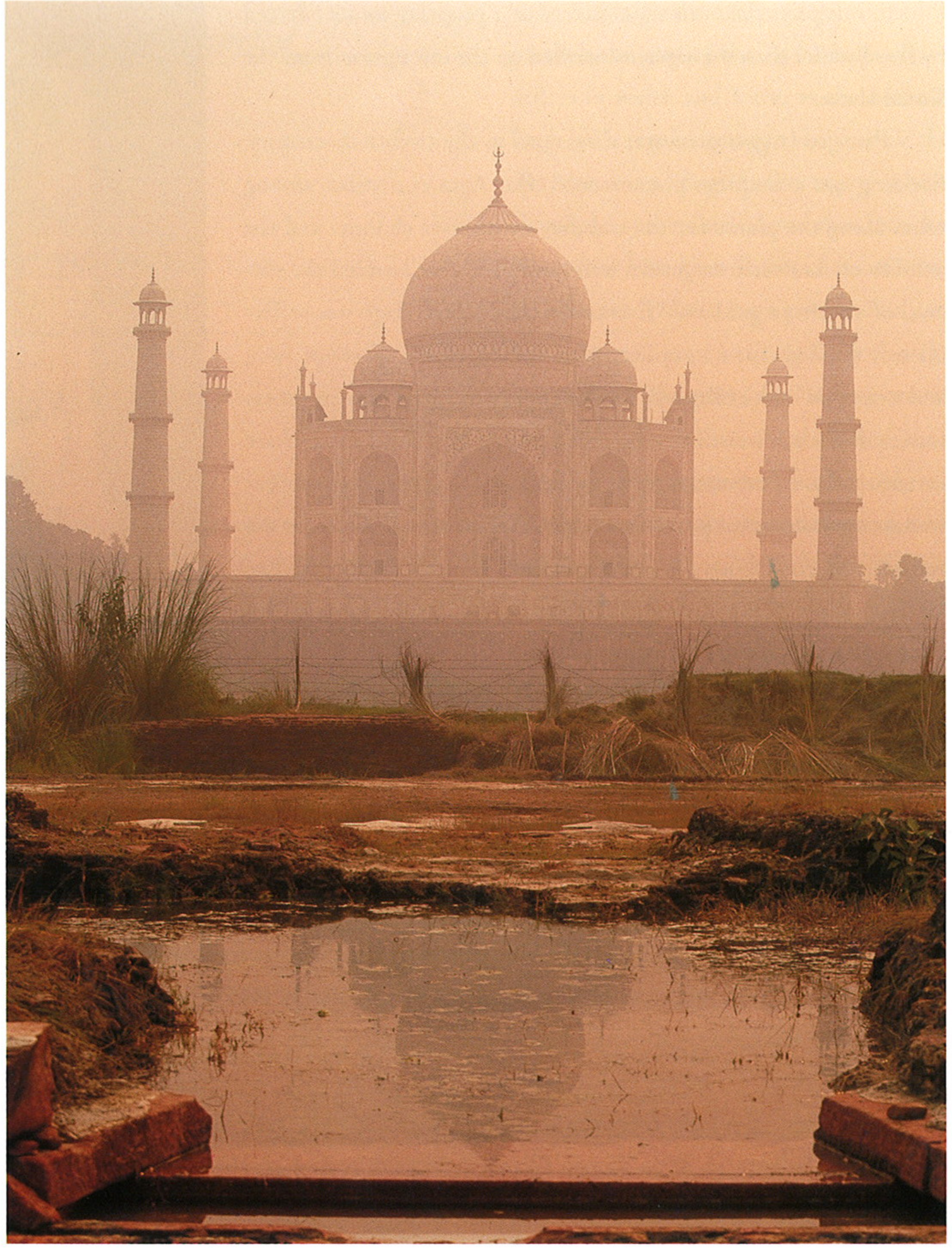


Figure 15. Reflections of the Taj Mahal in the Mahtab Bagh pool, 1999. Photograph by Neil Greentree

actual situation, she converts, saying, "I submit with Solomon to Allah, Lord of the Creation" (Koran 27:44, trans. Abdullah Yusuf Ali). Reflections of Taj Mahal minarets in the Yamuna and white marble fountains in the Mahtab Bagh pool repeat the common theme of "crossing over" in each of these interpretations.

Recent research has underscored the importance of patronage by women in Timurid art and architecture.[18] Ebba Koch has shown that the Ram Bagh, a garden upstream of Mahtab Bagh, was shaped by Queen Nurjahan (died 1645, wife of the fourth Mughal ruler Jahangir) and that Zahra Bagh, another upstream garden, was built by Princess Jahanara (died 1681, daughter of Mumtaz Mahal and Shahjahan).[19] This pattern of garden patronage raises questions about Jahanara's possible role at Mahtab Bagh as well. From a purely material standpoint, Mahtab Bagh had a riverfront landing like the Zahra Bagh (fig. 16). From an experiential standpoint, royal women spent far more time in Agra than did Shahjahan, at least until his confinement in the Red Fort. As her mother's tomb and the first monumental tomb built for a Mughal queen, the Taj Mahal may have had special significance for Jahanara and other women of the royal family.

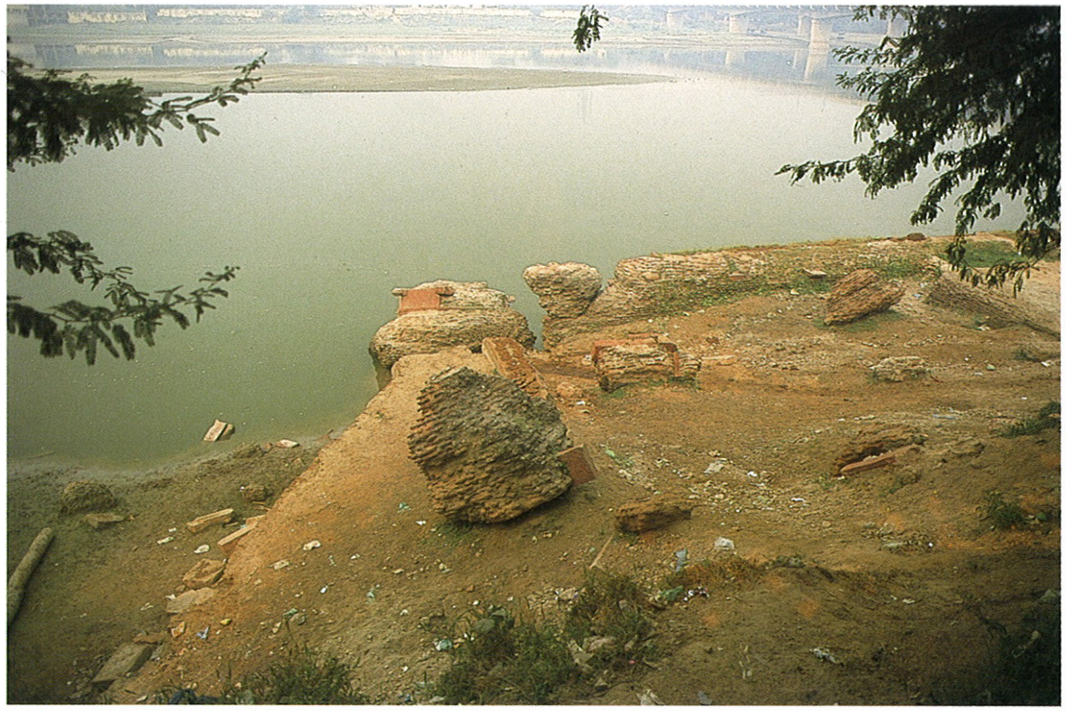


Figure 16. Riverfront landing at the Zahra Bagh, Agra, 1998. Photograph by James L. Wescoat

POETICS AND PRACTICALITY IN MUGHAL WATERWORKS

It is We that sent Sechina [tranquility] into the hearts of the believers,
that they may add faith to their faith for to God belong the hosts of the heavens
and the earth;
and God is full of knowledge and Wisdom.
That He may admit the believers, men and women alike,
to the gardens of Paradise, beneath which rivers flow,
to dwell therein forever.

KORAN 48:4–5, *inscription, inner southeastern arch, Taj Mahal*

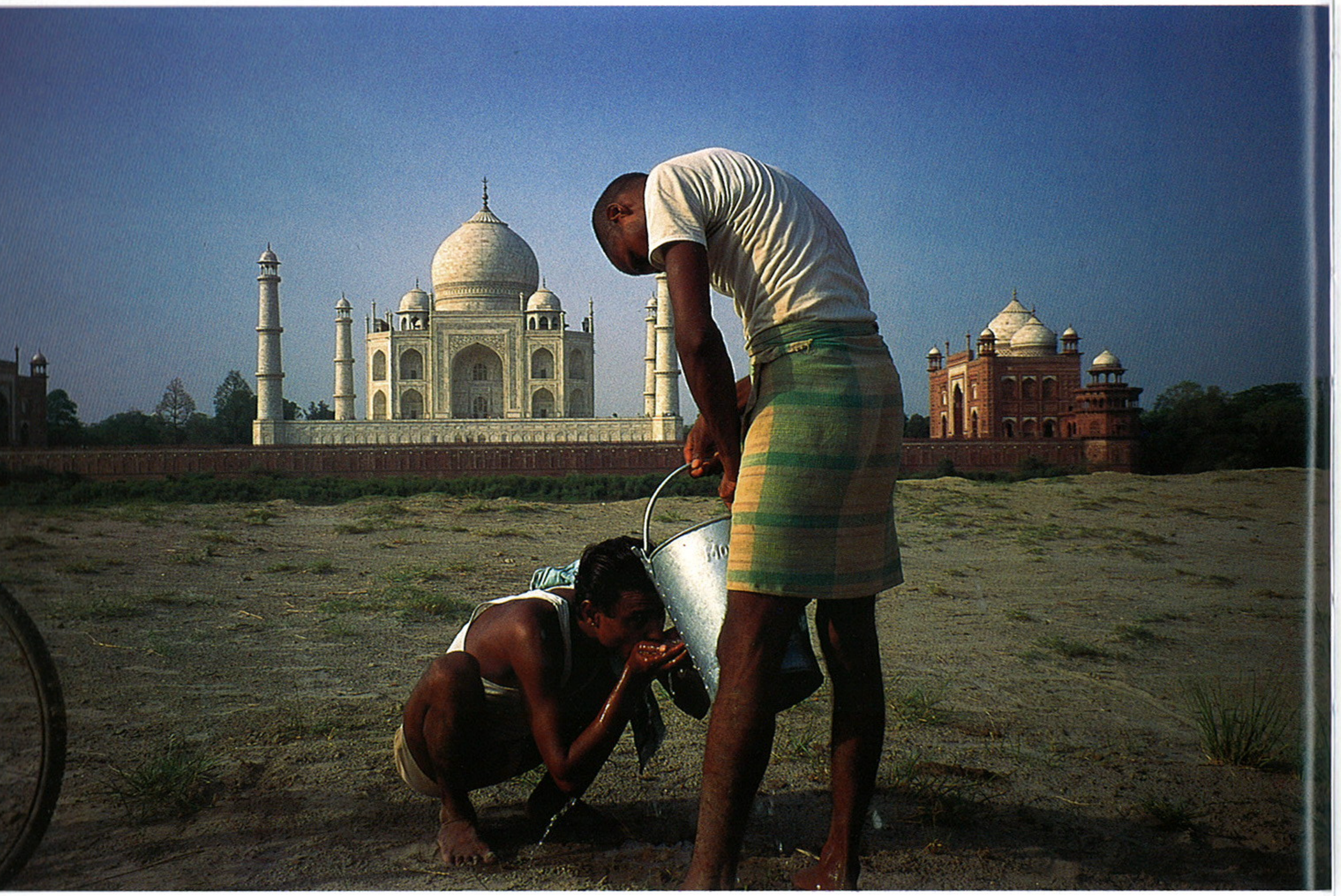


Figure 17. Man pouring a drink of water at the Mahtab Bagh, 1998. Photograph by James L. Wescoat

Waterworks are an essential feature of Mughal gardens. Understanding them involves a mix of poetics and practicality. Much of this essay has focused on the latter, asking how much water was needed, how was it supplied, and how did the system work? These themes require an appreciation of climate and hydrology that the Mughals did not have at the time of Babur's invasion but that they quickly learned and adapted at sites like the Mahtab Bagh. Success could not be assumed or assured. The seventeenth-century European traveler William Finch attributed abandonment of Fatehpur Sikri, the Mughal ceremonial capital constructed by Akbar just forty kilometers west of Agra, to its insufficient water supply. Although he may have exaggerated the significance of water problems in Akbar's decision to move to Lahore, water problems may nevertheless have been severe.[20]

Research on Mughal waterworks today requires a similar balance of poetics and practicality. The Taj Mahal and its environs are a primary tourist destination in India. Tourists are drawn by stories of romance but repelled by environmental degradation. The Supreme Court of India has established a regional protected area, known as the Taj Trapezium, and a series of decrees addressing industrial pollution, land use planning, removal of shopkeepers from the Taj forecourt, and establishment of a greenbelt that encompasses part of the Mahtab Bagh site. The most recent Supreme Court case *M. C. Mehta v. Union of India* (December 31, 1997) requires 292 industries to convert to natural gas power within a twelve-month period or shut down and compensate laid-off workers. Concurrently, the government of India has launched a Yamuna Action Plan, with financial support from the Japanese government. This plan seeks to increase the quantity and reliability of water delivered to Agra, maintain minimum flows and water quality standards in the Yamuna, and reduce untreated waste disposal from upstream cities and industries. Untreated waste is often said to be the only water that reaches the river at Agra in the low-flow months of May and June.

But have these Supreme Court mandates accelerated beyond our understanding of the historical and modern landscape? Proposals to build barrages to create flatwater reaches in Agra for tourism purposes, for example, raise numerous ecological as well as economic issues. In 1998, the Archaeological Survey of India Horticulture Department sank tube wells to irrigate extensive new plantings "in the Mughal style."

The practical questions are: How much water is needed? At what rates and times? To support what types of plantings? And with what effects on surrounding village water supplies? (See fig. 17.) The poetic questions are: How was the garden actually experienced in Mughal times? What beauty and meanings does it have for nearby villagers today?[21] What new beauty and meanings might be envisioned and realized there tomorrow? Perhaps Mahtab Bagh is a place where the poetics and practicality of Mughal waterworks could flow together, uniting the peoples and places of Agra with visitors from around the world. ⊠

NOTES

My first research on Mughal gardens in 1984 focused on waterfront gardens in Agra. Fellowships from Dumbarton Oaks and the Arthur M. Sackler Gallery, and encouragement from Milo C. Beach and Francine Berkowitz, helped me get started, and Elizabeth B. Moynihan helped me to return to Agra on the Mahtab Bagh project in 1998 and 1999.

All translations of inscriptions from the Koran are from Wayne E. Begley and Ziyauddin A. Desai, eds., *Taj Mahal, The Illumined Tomb—An Anthology of Seventeenth Century Mughal and European Documentary Sources* (Cambridge, Mass.: Aga Khan Program for Islamic Architecture, 1989), which follow the translations of Abdullah Yusuf Ali and Arthur J. Arberry.

1. Ebba Koch, "The Mughal Waterfront Garden," in *Gardens in the Time of the Great Muslim Empires: Theory and Design,* ed. Attilio Petruccioli (Leiden: E. J. Brill, 1997), pp. 140–60; Koch, "Tadj Mahall," *Encyclopedia of Islam,* new ed. (Leiden: E. J. Brill, 1998), 10:58–60.

2. For discussion of the *charbagh* concept, see Elizabeth B. Moynihan, *Paradise as a Garden in Persia and Mughal India* (New York: George Braziller, 1979); and James L. Wescoat Jr. and Joachim Wolschke-Bulmahn, eds. *Mughal Gardens: Sources, Places, Representations, and Prospects* (Washington, D.C.: Dumbarton Oaks, Research Library and Collection, 1996).

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4. Dennis J. Shea and N. A. Sontakke, *The Annual Cycle of Precipitation over the Indian Subcontinent: Daily, Monthly, and Seasonal Statistics,* NCAR/TN-401+STR (Boulder, Colo.: National Center for Atmospheric Research, Climate and Global Dynamics Division, 1995).

5. C. Sharma, "Recent Pollen Spectra from Garhwal Himalaya (India)," *Geophytology* 15, no. 1 (1985): 87–97.

6. James L. Wescoat Jr., Michael Brand, and M. Naeem Mir, "The Shahdara Gardens of Lahore: Site Documentation and Spatial Analysis," *Pakistan Archaeology* 25 (1993): 333–66.

7. Map of Agra, 18th century, City Palace Museum of Jaipur. See Chandramani Singh, "Early 18th Century City Maps on Cloth," in *Facets of Indian Art,* ed. R. Skelton et al. (London: Victoria and Albert Museum, 1986), pp. 185–92. See also A. C. L. Carlleyle, *Agra: Report for the Year 1871–1872,* vol 4. (Reprint Varanasi: Indological Book House, 1966).

8. Ram Nath, *Agra and Its Monuments* (Agra: Historical Research Documentation Programme, 1997), pp. 122–24.

9. Milo Cleveland Beach, Ebba Koch, and Wheeler M. Thackston, *King of the World: The Padshahnama, An Imperial Mughal Manuscript from the Royal Library, Windsor Castle* (London: Azimuth Editions; Washington, D.C.: Arthur M. Sackler Gallery, 1997), p. 63.

10. There have been few empirical or archaeological studies of Mughal fountains. The principal one to date occurred at Shalamar Garden, Lahore, by Syed Dildar Hussain, Nurul Mustafa, and Naeem Ahmad Khan, *Leakage Investigation at Shalamar Garden, Lahore Using Radioisotopes* (Rawalpindi: Pakistan Institute of Nuclear Science and Technology, 1979); see also Ihsan H. Nadiem, "The Hydraulics of Shalamar Garden," *Pakistan History and Culture* 34 (1986): 1–13.

11. "The Taje Mahel, Agra," originally published as a colored aquatint (53.3 x 87.6 cm) in *Views of the Taje Mahel at the City of Agra in Hindoostan taken in 1789,* reprinted in Mildred Archer, *Early Views of India: The Picturesque Journeys of Thomas and William Daniell, 1786–1794* (New York: Thames and Hudson, 1980), fig. 29, pp. 68–69.

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13. For a fuller treatment of floods and other hazards see C. M. Agarwal, *Natural Calamities and the Great Mughals* (Bodh Gaya: Kanchan Publications, 1983).

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17. Koch, "Mughal Waterfront Garden," p. 144.

18. Lisa Golombek, "The Gardens of Timur: New Perspectives," *Muqarnas* 12 (1995): 137–47; Golombek, "Timur's Gardens: The Feminine Perspective," in *The Mughal Garden: Interpretation, Conservation and Implications,* ed. Mahmood Hussain, Abdul Rehman, and James L. Wescoat Jr. (Lahore: Ferozsons Ltd., 1996), pp. 29–36; Roya Marefat, "Timurid Women: Patronage and Power," *Asian Art* 6, no. 2 (Spring 1993): 28–49; Ellison Findly, *Nur Jahan: Empress of Mughal India* (Oxford: Oxford University Press, 1993).

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20. Michael Brand and Glenn D. Lowry, *Fatehpur-Sikri: A Sourcebook* (Cambridge, Mass.: Aga Khan Program in Islamic Architecture, 1985), pp. 213–4. See also Attilio Petruccioli, *La Citta' del Sole e Delle Acque: Fathpur Sikri* (Rome: Carucci Editore, 1988), pp. 54–59.

21. J. S. Bhandari, "An Ethnographic Study of Nagla Devjit, Nagla Kachchpura, and Garhi Chandni," unpublished report for the Agra Heritage Project (Delhi: Department of Anthropology, University of Delhi, 1993).